REMOVAL OF METALS AND METALLOIDS BY Mg-Fe LAYERED DOUBLE HYDROXIDES

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Keywords: layered double hydroxides; adsorption isotherms; adsorption edges; metals; metalloids

Introduction

Contamination of soils and waters by metals and metalloids is an important environmental problem due to their toxicity, mobility and non-degradability in ecosystems. In contrast to standard remediation methods, chemical stabilization using solid materials enables an effective, safe and low-cost removal of these hazardous elements (Komárek et al., 2013). Layered double hydroxides (LDH) show high removal effectivity for various metals and metalloids (Goh et al., 2008; Liang et al., 2013). The main aim of the study is to combine adsorption modelling with the analysis of the solid phase in order to investigate the adsorption mechanism of As, Pb and Zn by Mg-Fe LDH.

Methods

The Mg-Fe LDH was successfully prepared using the co-precipitation method described in Seida et al. (2001). Subsequently, kinetic adsorption experiments, equilibrium adsorption experiments, including the construction of adsorption edges, were performed. The experiments were carried out in individual batches at a controlled pH value and $NaNO_3$ was used as the background electrolyte (0.001 – 0.1 M). The solid/liquid ratio in all experiments was 1 g/L and equilibrium was reached after 120 min. Analyses of the solid phase were performed using various methods including XRD, SEM/EDX, FTIR-ATR and XPS.

Results

Adsorption kinetics data were successfully described by the pseudo-second kinetic order model. The adsorption efficiency of As, Pb and Zn in the kinetic experiment was 99%, 98% and 77%, respectively. All measured isotherms exhibited a concave shape and Langmuir, Freundlich and their combination (Sips) were chosen as appropriate models (Foo, Hameed, 2010). Adsorption isotherms fitted by the Langmuir, Freundlich and Sips model are given in Figure 1. Based on the results, Freundlich and Sips models show better fits than Langmuir model. On the other hand, the adsorbed amount of As and Zn predicted by the Sips model (3.22 and 3.51 mmol/g) is overestimated according to experimental values (1.75 and 1.19 mmol/g).

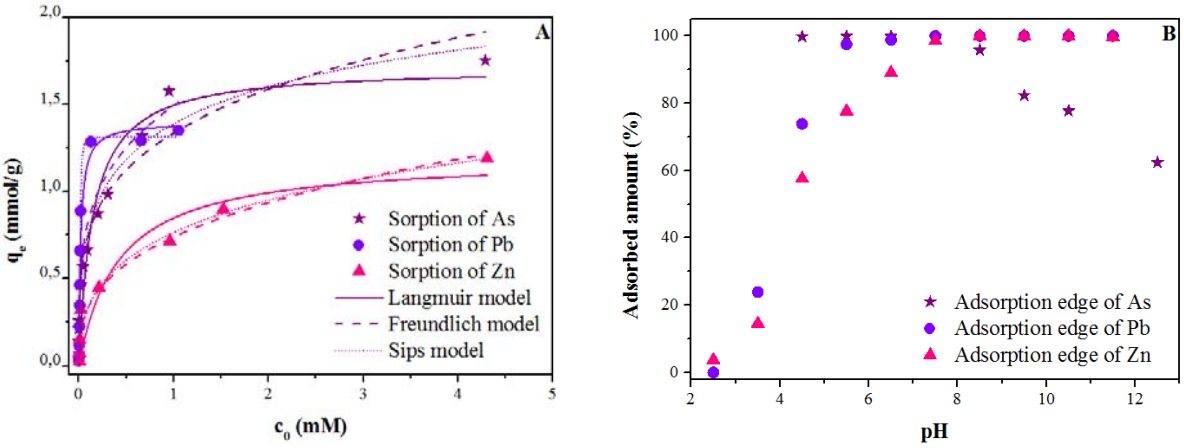

Figure 1. Adsorption isotherms fitted by Langmuir, Freundlich and Sips model (A) and adsorption edges in 0.01 M $NaNO_3$ (B) of As, Pb and Zn on Mg-Fe LDH.

The adsorption edges (Figure 1) showed characteristic shapes, i.e., increasing As sorption at lower pH values and decreasing for Zn and Pb. The samples chosen for the analysis of the solid phase showed relatively high sorption capacities (2.13 mmol/g for As, 1.65 mmol/g for Pb and 1.44 mmol/g for Zn) comparable to other LDHs (Goh et al., 2008; Liang et al., 2013) thus a demonstrable effect of the adsorption process was expected. The XPS analysis confirmed adsorption of As, Pb and Zn on the surface of Mg-Fe LDH. Moreover, the influence of isomorphic substitution (Zn), ion exchange (As) and precipitation (Pb) was determined by XRD.

Conclusion

The study evaluated the removal efficiency of As, Pb and Zn from aqueous solution by Mg-Fe LDH. Based on our results, Mg-Fe LDH shows a promising adsorption capacity for all of these elements and the best fit was obtained using Freundlich and Sips model. Besides, the basic adsorption mechanism including adsorption, isomorphic substitution, ion exchange and/or precipitation was described. Future studies will be focused on further analyses of the solid phase (HR-TEM and/or EXAFS) and on the investigation of the SCM model in order to obtain a comprehensive description of the adsorption mechanisms.

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